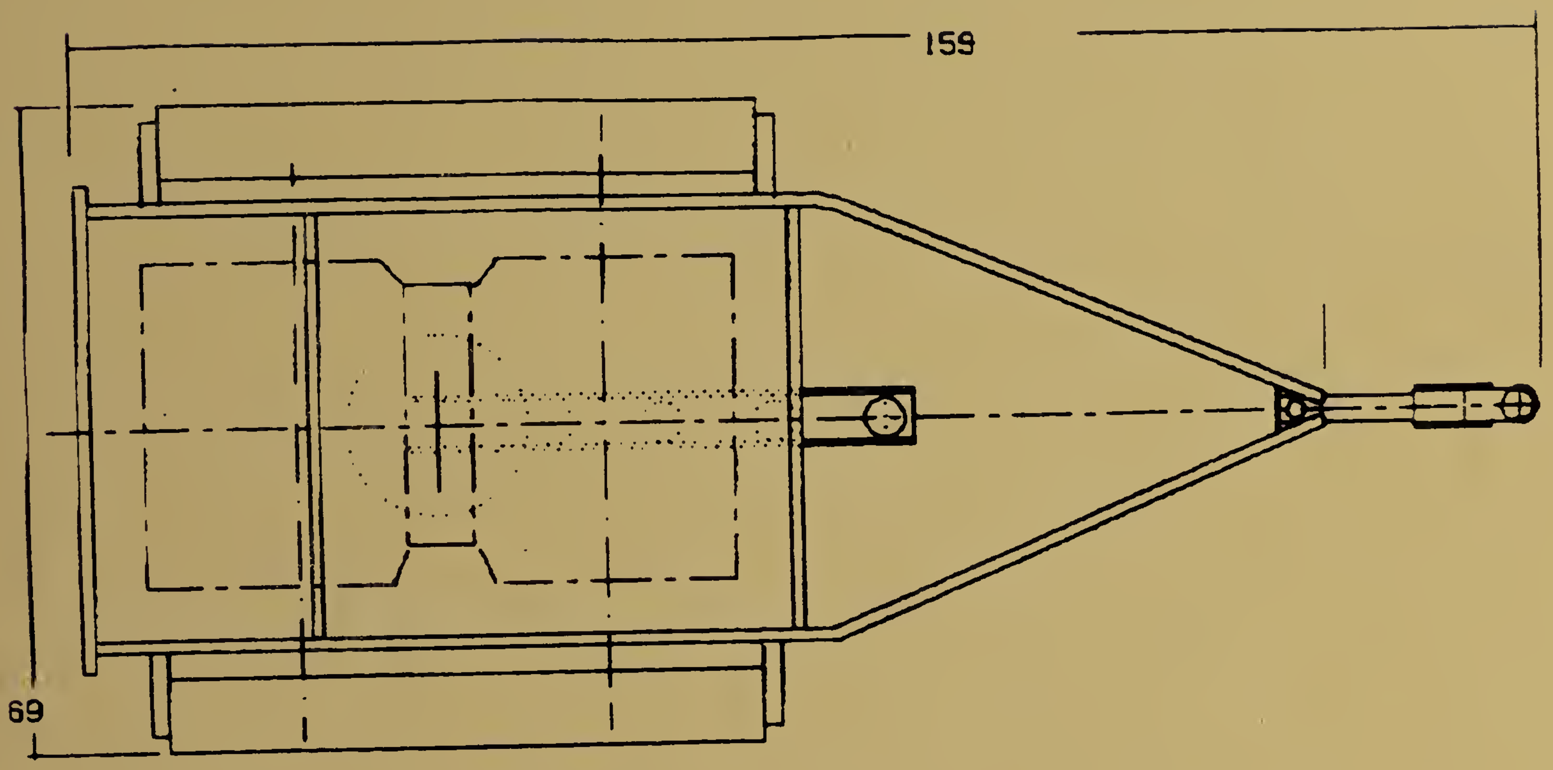
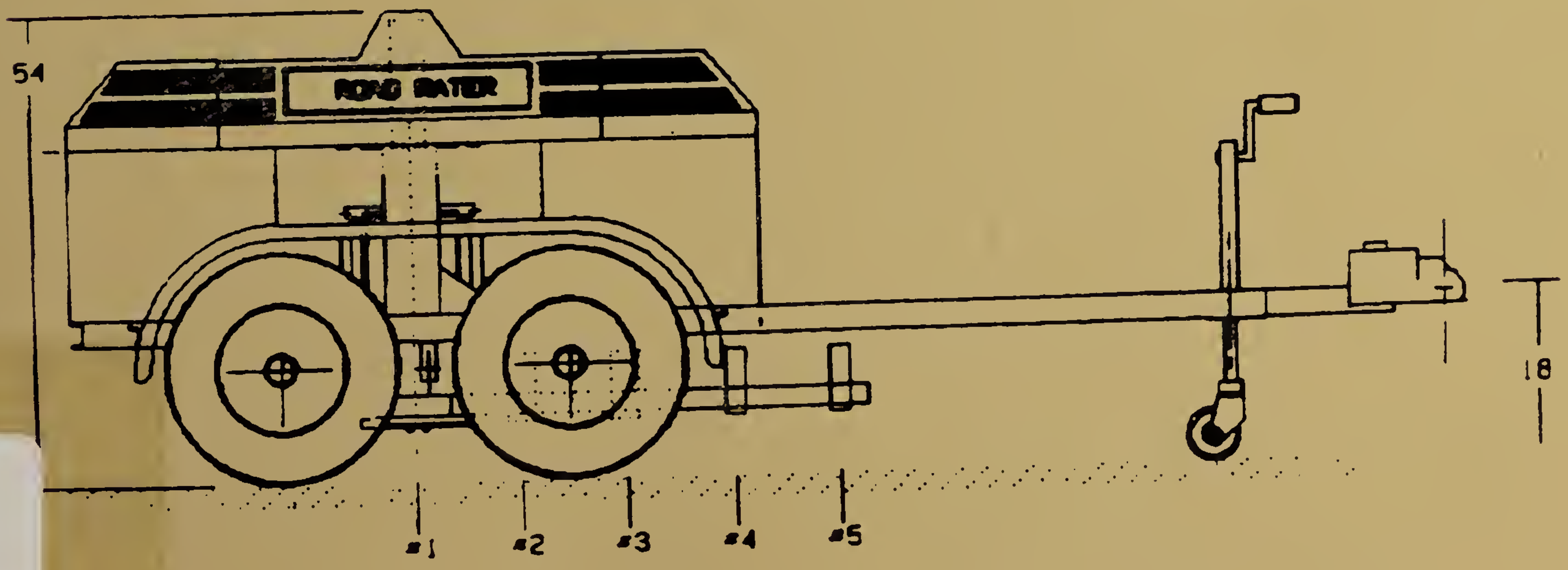
NDT BASED DESIGN PROCEDURE

AND

NETWORK EVALUATION

MANUAL





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NDT BASED DESIGN PROCEDURE

AND

NETWORK EVALUATION

MANUAL

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TABLE OF CONTENTS

INTRODUCTION i

PROJECT LEVEL

PAGE #

PHASE A - FIELD EVALUATION AND NDT TESTING 1

PHASE B - NDT DATA MANIPULATION AND INTERPRETATION . . . 10

PHASE C - DESIGN - LIFE, MichPAVE, DARWin 20

PROJECT LEVEL SUMMARY 24

NETWORK LEVEL

PHASE 1 - FIELD EVALUATION AND NDT TESTING 25

PHASE 2 - NDT DATA MANIPULATION 33

PHASE 3 - NDT DATA INTERPRETATION AND EVALUATION 35

PHASE 4 - NDT RESULTS FORMALIZATION AND TRANSMITTAL . . . 36

NETWORK LEVEL SUMMARY 36

Non-Destructive Testing(NDT) is an emerging technology that can benefit highway planners and designers in a variety of areas. Information generated through Non-Destructive Testing can be incorporated into a pavement management system or be utilized in the actual design of pavement structures. Road Rater type NDT equipment is used in conjunction with the MODULUS backcalculation program to generate the information required by MDT.

This manual addresses the two primary objectives of the Montana Department of Transportation's NDT Area. These objectives are:

1) Project Level Testing
   Evaluate all future construction projects and provide necessary information to ensure accurate and cost effective repair strategies are developed.

2) Network Level Testing
   Evaluate Montana's federal aid route system on a semi-annual basis to assist Pavement Management, long-range planning and programming.

The Project Level portion includes three major phases. Phase A activities are field evaluation and NDT testing; Phase B is NDT data interpretation and is the most extensive phase of the Project Level; and Phase C is the determination of the possible repair strategies.

The Network Level portion includes four major phases. Phase 1 activities are field evaluation and NDT testing; Phase 2 is data manipulation; Phase 3 is data interpretation and evaluation; Phase 4 is summary and results transmittal - This phase requires careful implementation because of the variety of interested receivers.

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PHASE A - FIELD EVALUATION AND NDT TESTING

Projects are included in the yearly testing schedule based on the following criteria:

1) All projects are tested as soon as possible after nomination.
2) Projects scoped for reconstruction are only tested once prior to their ready date.
3) All other surfacing design related projects are tested every 2 years up to 12 months prior to the ready date.
4) All seasonal monitoring sites are tested by the project Road Rater.
5) All NDT related SHRP requirements are tested by the project Road Rater.

Project Level Procedure

Primary → Test every 440′ one way and 880′ the other way.

Interstate → Test every 440′ each way. Eight tests in the driving lane and four tests in the passing lane

Before testing begins, the following needs to be determined:

* 1) all existing typical section changes must be determined

* 2) final record paving core log data is needed

* this information needs to be summarized, converted to mileposts and taken to the field

Equipment that is needed for testing and must be checked before leaving

- Drill (don't forget periodic maintenance)
- Bits 1/2" & 1", at least two of each
- Mineral Oil, at least one gallon, should be obtained before leaving Helena
- Digital & infrared thermometers with spare batteries
- The air pressure in the bladders on the Road Rater must be checked
- Check oil in small engine on Road Rater
- Check oil in towing unit
- Check hydraulic oil in trailer
- Check for periodic maintenance (service, PM) for both towing unit and trailer.

Flagging Requirements

A "follow" vehicle is provided by the NDT Area. A sign should be hung on the back of the "follow" vehicle. The "follow" vehicle should also have an amber flashing light and its flashers on at all times. If the "follow" vehicle does not have a two-way radio, then a hand held two-way radio should be provided.

The Road Rater towing unit must:

1) Raise the arrow board on the roof into operating position
2) Turn on the arrow board
3) Turn on the flashers and amber lights
4) Check the two-way radio to insure communication with the "follow" vehicle(s)

Spacing between the Road Rater and the "follow" vehicle should be determined by the Road Rater operator. It is recommended that the "follow" vehicle maintain an approximately 300′ gap and have its right side tires on the shoulder stripe. On hills and curves, there may be a minimum gap of 200 ft. However, the "follow" vehicle must be positioned so that approaching traffic has a minimum of 1000 ft. to sight the "follow" vehicle. Distances may vary because of roadway conditions and the operator's discretion.

Road Rater Set-Up

1) Start the Road Rater
2) Using the switch, raise the mass
3) Remove the safety pins. There is one on each side located just above the front tire. Lift the pin up, then slide it out approximately 1½".

4) Lower the mass using the switch

5) Install the mast containing the five sensors

be sure to latch the sensor mast in place

6) Turn off small engine and proceed with computer set-up

Computer Set-Up

1) Turn on the power converter

2) Turn on the PC and printer

3) All testing should be done with the printer on line

4) At the menu select the correct function for the project

5) Follow the directions and fill in all necessary data

*Note The file name for the projects will be the control number for the project being tested, proceeded by a letter representing the year tested, e.g., K2164

Temperature and Depth Determination

1) Change the drill bit size to 1".

2) Bore a hole completely through the mat.

3) Using the calibrated depth gauge, measure the asphalt thickness.

4) Changing to a 1/2" drill bit, drill a 1/2" diameter hole 1/2 the measured mat thickness + 1".

5) Pour approximately a 2" depth of oil in the 1/2" hole.

6) Allow X minutes for the oil to reach equilibrium.

7) Put the temperature probe in the oil and turn on the thermometer.

8) Read the normalized mean asphalt temperature.

9) Record the thickness and temperature on the form and in the computer.

10) Begin the testing sequence -- refer to the diagram on the dash of the towing unit if there are questions about the sequence.

11) At each milepost, monitor the surface temperature. When there is a 10° F variation from the last surface temperature at the previous drilling location, temperature drilling must be repeated.

12) On the note comment at the MP locations, use this format: Note: MP110 SURF71 (comments if needed).

13) At each surfacing thickness change (based on the as-builts), depth drilling must be repeated.

Surface Distress Monitoring

The condition survey and distress identification activities should document all detected conditions. Comprehensive pavement condition survey methodologies have been developed and a standard procedure for recording this information is available from the Pavement Management Unit. Minor modifications have been made because of the increased frequency in observations during NDT testing.

- Surface distress at each testing location should be recorded. Refer to the surface distress rating manual for the proper recording of the distress.
- Location of distress, presence of cuts or fills, presence of water, maintenance activities and other possible abnormalities should also be recorded.
- Surface distress abbreviations:

  ALG = Alligator cracking

  LONG = Longitudinal cracking

  POT = Pot holes

  PCH = Patch

  RUT = Rut

  TRI = Transverse cracking
- Other useful abbreviations:

  BR = Bridge

  CL = Centerline

  CUT = Cut

  FILL = Fill

  MP = Milepost

  WP = Wheel path

  AH = Ahead

  BH = Back

  Water = Water (water location and amount should also be noted)
- In addition to the above abbreviations, extent and severity must also be recorded.

If possible, NDT testing should be conducted during the spring period. Because of the volume of testing required for the Project Level, Montana must test beyond the spring period. However, no Project Level testing can be performed when there is a potential of frost within any pavement layer or the subgrade.

NDT at several times during the different seasons establishes a "seasonal effect" pattern which may be used to enhance some design procedures. Caution must be used when basing decisions on "seasonal effect" patterns since soil class influences the impact of the seasons.

Testing Procedure

1) Begin 0.10 mile after the beginning of the project.

*2) Always put the suburban in park prior to testing; after testing is completed and beeper stops, suburban may be put into gear.

3) When asked for the station, enter the test number.

4) Enter the lane number. Skip one number for the median or the centerline.

5) Enter the note. This is the area to enter the distress, temperatures, etc. Refer to "Temperature and Depth Determination" and "Surface Distress Monitoring."

6) Perform the testing.

7) Check the deflection recordings. If the deflections are in descending order, then accept the test. If the deflections are not, then reject and retest.

8) Continue with temperature and depth monitoring as previously directed.
9) Repeat the testing procedure at the designated intervals.
10) End the testing 0.10 mile before the end of the project.
11) Edit all files in the field at the end of the project or the end of the day so any problems can be detected while the Road Rater is still in the area.

Shut Down Procedure

1) Move the Road Rater and towing unit as far off the roadway as possible
2) Turn the computer off
3) Manually lower the mass
4) Remove the mast and the sensors
5) Manually raise the mass and turn off the Road Rater engine
6) Insert the pins to secure the mass
7) Lower and secure the arrow board on the towing unit
8) Turn off the arrow board and flashers
9) Remove signs and turn off all warning lights on the flagging vehicle

Because of the number of lane miles in Montana's highway network, complete monitoring will be accomplished on a two-year cycle. The NHS system will be rated on odd numbered

years and the STP system will be rated on even numbered years. Seasonal testing and soil class testing will be performed on a yearly basis.

After the days testing operations are complete, or at the end of the project, the data must be backed up on a separate disk. This step is critical to insure all data is safe and retrievable.

PHASE B - TRANSFER OF DATA

This step is required to transfer raw field data to the network computer in the required format(s).

1) The network must be connected
2) Go to NDT Network Menu
3) Go to NDT Project Menu
4) Select Edit Raw R.R. Data on Disk
5) Select the drive the raw data disk will be in
*6) Enter the name of the file to be checked/edited
7) Save all changes (F3)
8) Convert the edited raw data format
    - designate the location of the edited raw data
    - designate the appropriate district and classification
    - enter the edited raw data file name
9) Follow the menu direction until conversion is complete
10) Repeat steps 1 thru 9 until all files are converted

* using SPFPC, the raw data must be checked for sequential test numbers, checked for sequential milepost comments, and make any other required corrections.

The "whereis" function should be used periodically as a check of the system. This will ensure that the converted files are being copied as directed.

Resilient Modulus Backcalculation

Montana Department of Transportation uses a modified version of a microcomputer based backcalculation procedure called MODULUS. MODULUS was developed by the Texas Transportation Institute. MODULUS uses a linear-elastic program to generate a database of deflection bowls. The size of the database depends on the user-supplied range of acceptable modulus values for each layer. Once the database is generated, a pattern search routine is used to fit measured and calculated bowls. The system developed by Montana is designed to accept the converted Road Rater raw data and directly read the mean asphalt temperature. In addition to the above mentioned changes, the temperature correction routine used by WASH.DOT in their program EVERCALC was incorporated into the MODULUS program to facilitate normalizing the plant mix resilient modulus at 77° F.

The ultimate goal of the backcalculation process from NDT results is to estimate the pavement material properties. The procedure is to find the set of parameters which correspond to the best fit of the measured deflection bowls. The best fit is achieved by minimizing the error between the measured and calculated deflection bowls.

- USING MODULUS
  - Select the MODULUS Backcalculation Menu
  - Select MODULUS 4.0
  - Select the respective District, and Route type

- Select the Project

At this point the operator is now in the MODULUS program. Because backcalculation is an iterative process and because backcalculation is somewhat time consuming, only the first 5 or 6 uniform tests should be analyzed at first.

A full analysis is typically performed. Therefore, only a full analysis is addressed in this manual. For guidance on the other design options, refer to the MODULUS users manual.

Select "Run a full analysis"
The function keys (F1,F3,F4) allow the user to move within the screen
Input Items:

*Plate Radius - 6.00"

Number of Sensors - determined from the data file but typically 6

*Sensor Distance from Plate - 0,8,12,24,36,48

Weight Factor - the user may wish to assign weight factors to each sensor or let the program assign them automatically. Leave all the weighting factors at zero for automatic assignment. If the user wishes to override this, he simply inputs the desired factor which typically ranges from 0 to 1.0. MDT typically assigns a weighting factor 1.0 to all sensors thus placing equal importance on each.

user wishes to override this, he simply inputs the desired factor which typically ranges from 0 to 1.0. MDT typically assigns a weighting factor 1.0 to all sensors thus placing equal importance on each.

Layer Thicknesses - the thickness of each layer within the surfacing section must be determined and entered at this time. AS-BUILT THICKNESSES ARE NOT ADEQUATE. Plant mix thickness can be obtained from the drilling results that were performed at the time of testing or from recent core reports. The second thickness typically represents the base course. For backcalculation purposes, the crushed top surface and crushed base course are combined into one representative thickness. The base thickness is obtained from the soil survey, field testing, core drill results or historical records. In many cases, a third layer will not exist and H3 will remain 0.0. The H4 value is automatically calculated and represents the depth in the pavement structure at which a still layer is calculated to occur. This layer may be bedrock or a stiff clay for example. Based on extensive research by Texas Transportation Institute (TTI), it is clear that an estimate should be made for the depth to bedrock for each section under analysis. This estimate does not need to be precise but simply classifies pavements into

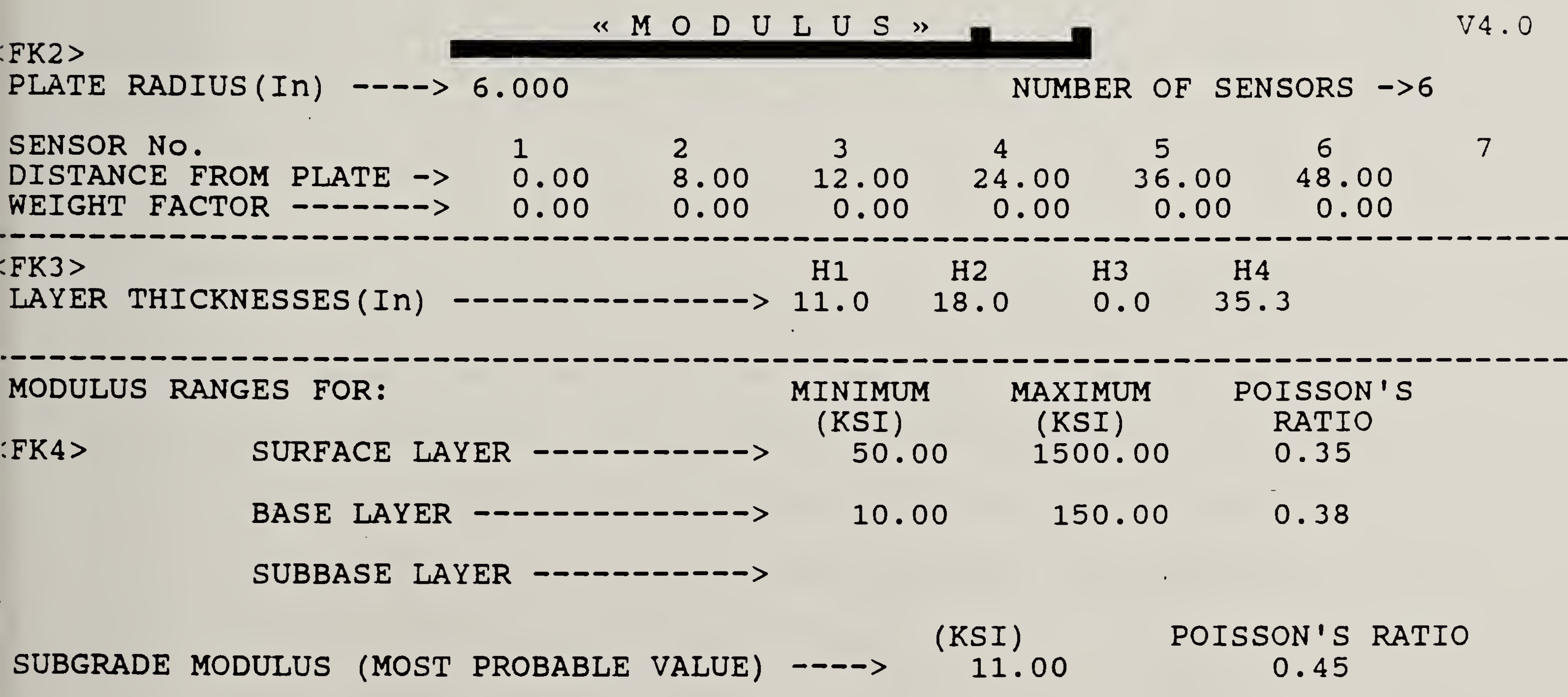
Estimated Layer Moduli - programs such as MODULUS require an acceptable range of layer moduli to be provided or "seed" moduli in the case of the subgrade. The surfacing layer, base layer, and subbase layer require a minimum and maximum resilient modulus in the form of KSI (thousand pounds per square inch). Also required is the Poissons ratio for each material type. Guidelines follow:

	MIN (KSI)	MAX (KSI)	Poissons Ratio
PCCP	500	4,000	.25-.20
PMS	75	750	.38-.30
CTB	50	1,500	.38-.25
cement enhanced base	25	250	.40-.30
crushed base course	10	50	.43-.38
special borrow	5	50	.45-.38

* Projects tested prior to August 23, 1993 may have used a 4.22" plate radius and different sensor spacings. Refer to the project summary sheet to determine the applicable plate radius and sensor spacings.

It should be noted that when running the MODULUS program, it is essential that a wide enough range of moduli be used. If the range is too narrow, the resilient moduli will limit out at either the top or the bottom of the range and the numbers will not be correct. In these cases, the acceptable range

should be further investigated. Next, enter the most probable modulus value in KSI and the corresponding Poissons ratio for the subgrade material. Although it is known that the subgrade resilient modulus will vary from location to location, incorrect assumptions of the subgrade resilient modulus do not appreciably effect the backcalculation outcome. For this reason, an educated guess -- based on soils information, historical Road Rater information, or adjacent project information is an adequate source for this input. After entering the value, check all inputs and if necessary make all required changes using the appropriate function key(s). Once you are satisfied with all inputs, press <ENTER> to execute the program. An example worksheet displaying these procedures follows:



```
                              « M O D U L U S »                            V4.0
FK2>
PLATE RADIUS(In) ----> 6.000                          NUMBER OF SENSORS ->6

SENSOR No.                1       2       3       4       5       6       7
DISTANCE FROM PLATE ->   0.00    8.00   12.00   24.00   36.00   48.00
WEIGHT FACTOR ------->   0.00    0.00    0.00    0.00    0.00    0.00
-------------------------------------------------------------------------------
FK3>                                     H1      H2      H3      H4
LAYER THICKNESSES(In) ---------------> 11.0    18.0     0.0    35.3

-------------------------------------------------------------------------------
MODULUS RANGES FOR:                     MINIMUM    MAXIMUM    POISSON'S
                                         (KSI)      (KSI)       RATIO
FK4>         SURFACE LAYER ----------->   50.00    1500.00      0.35

             BASE LAYER -------------->   10.00     150.00      0.38

             SUBBASE LAYER ----------->

                                               (KSI)       POISSON'S RATIO
SUBGRADE MODULUS (MOST PROBABLE VALUE) ---->   11.00           0.45
```

When the program is complete, select the appropriate view option from the following menu and analyze the backcalculated moduli:

```
SELECT OPTION:
[1]   - MERGE & RETURN TO MODULUS
[2]   - MERGE & RUN REPORT
[3]   - VOID & RETURN TO MODULUS
[4]   - VOID & RUN REPORT
[5]   - VIEW J884.DAT  FILE
[6]   - VIEW J884.RPT  FILE
  [Esc]   - EXIT TO DOS
```

An example of option [5] - VIEW J884.DAT FILE follows:

```
  1.000    3049  2.74  2.56  2.29  1.77  1.44  1.13   .00   718855.    50696.     3240. &
  2.000    3059  1.95  1.61  1.37   .91   .65   .46   .00   507805.    67132.    10946. &
  3.000    3049  1.95  1.61  1.33   .84   .53   .32   .00   523047.    36213.    18013. &
  4.000    3059  2.20  1.86  1.68  1.18   .84   .55   .00   660959.    35240.     9484. &
  5.000    3069  2.52  1.94  1.71  1.03   .63   .38   .00   375750.    31423.    15071. &
  6.000    3069  1.73  1.41  1.25   .76   .46   .27   .00   661753.    28131.    23916. &
  7.000    3019  1.68  1.40  1.28   .89   .64   .43   .00   805475.    54482.    11524. &
  8.000    3019  1.54  1.19  1.05   .63   .39   .23   .00   616678.    48171.    24611. &
  9.000    2979  1.35   .98   .83   .47   .29   .18   .00   524219.    80907.    30007. &
 10.000    3039  1.16   .98   .80   .53   .39   .29   .00   789477.   131081.    16954. &
 11.000    3069  1.79  1.31  1.14   .67   .40   .23   .00   461692.    50268.    24186. &
 12.000    3019  1.39  1.03   .90   .55   .36   .23   .00   573752.    86125.    22567. &
 13.000    3029  1.43  1.30  1.00   .65   .44   .30   .00   728994.    59143.    18910. &
 14.000    2989  1.42  1.07   .95   .61   .42   .28   .00   585046.    95210.    17394. &
 15.000    2999  1.26   .94   .82   .49   .30   .20   .00   635901.    84712.    27324. &
 16.000    3029  1.61  1.25  1.10   .68   .44   .28   .00   574629.    59456.    19154. &
 17.000    2999  1.35  1.00   .86   .56   .36   .23   .00   591641.    92047.    21745. &
```

If the moduli appear unrealistic, repeat the procedure making appropriate input modifications. If the moduli appear reasonable, merge the data and continue to the next section. If the program has uniform characteristics throughout, then the entire data set for a particular direction can be run at one time.

Repeat the entire procedure for the other direction (back).

When all deflection data has been analyzed, select the appropriate report activity. The menu appears as follows:

```
                Current Project Name:  J887


     [T]   - RUN REPORT w/  MAT TEMPERATURE ADJUSTMENT
     [R]   - RUN REPORT w/o MAT TEMPERATURE ADJUSTMENT
     [C]   - CHANGE PROJECT NAME (current shown above)
     [E]   - EDIT REPORT (Eliminate Tests & Add Notes)
     [V]   - VIEW REPORT DATA FILES (*.RPT & *BK.RPT)
    [Esc]  - EXIT Modulus Report Program (Exit to DO


                   MODULUS-REPORT-MENU
```

Editing the report may be required for several reasons, the most common are:

1) unacceptably high error (determined by MODULUS)

*2) unrealistic Mr on any layer - high or low

3) Modification of the maximum or flag Mr for any layer

4) Tests to be eliminated are those that are two times the standard deviation, either above or below the average for that particular project.

- * if any one moduli at any test site appears to warrant elimination, then the entire test (all layers) should be physically deleted.

Typical maximum Mr and flag values follow:

Material	Maximum Mr	flag Mr
PCCP	2,000,000-5,000,000	500,000-1,000,000
CTB	1,000,000-3,000,000	500,000-750,000
PMBS	300,000-500,000	100,000
Cement Enhanced Material	200,000-500,000	50,000-100,000
Base Material	25,000-50,000	15,000-20,000
Subgrade	10,000-30,000	2,000-10,000

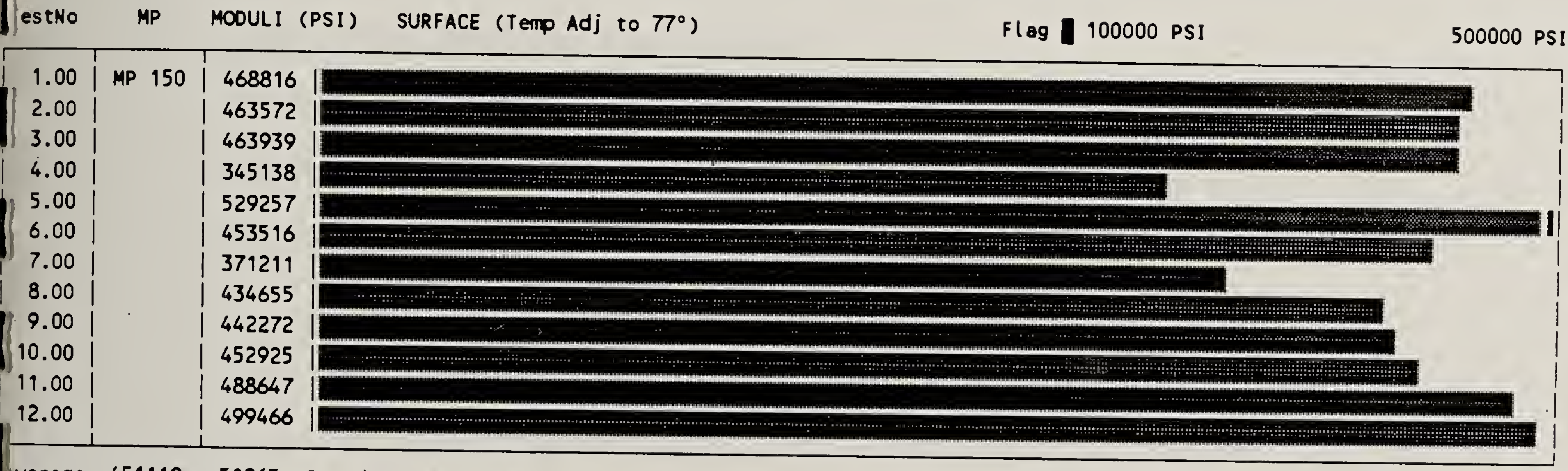
After all necessary editing is completed, the report should be printed.

The report should typically be run utilizing the temperature adjustment option. This option will provide the calculated resilient modulus for each layer at each test site in addition to the plant mix resilient modulus normalized to 77°F.

An example of a report showing surface moduli, base material moduli and subgrade material moduli follows. Note the report was run with temperature adjustments incorporated.

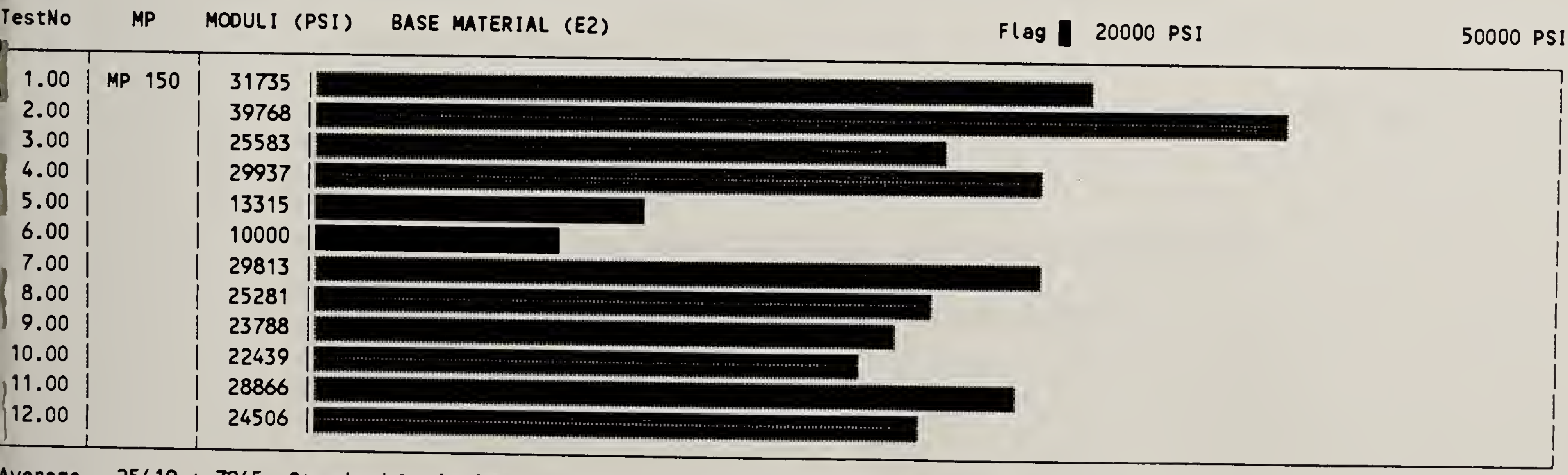
```
                                            Using EVERCALC 3.3 Eq. for WSDOT class B
                            MatTemp    Adj-77°     Base       SubGrade
        TestNum   MatTemp   Modulus    Modulus     Modulus    Modulus
.............................................................

        1.000     74°F      546711     468816      31735      13457
        2.000     74°F      540595     463572      39768      13256
        3.000     74°F      541023     463939      25583       6590
        4.000     74°F      402483     345138      29937       7158
        5.000     74°F      617194     529257      13315      13312

        6.000     74°F      528868     453516      10000       5238
        7.000     74°F      432888     371211      29813      13540
        8.000     74°F      506873     434654      25281      11727
        9.000     74°F      515756     442272      23788      10299
       10.000     74°F      528179     452925      22439      15506

       11.000     74°F      569837     488647      28866       8835
       12.000     74°F      582453     499466      24506      19529

.............................................................
     Average      74°F      526072     451118      25419      11537
 Standard Deviation  0°F     59316      50865       7943       4108
```

```
File:  J884 Date: 10-06-1993 Time: 13:53:19
............................................................
```

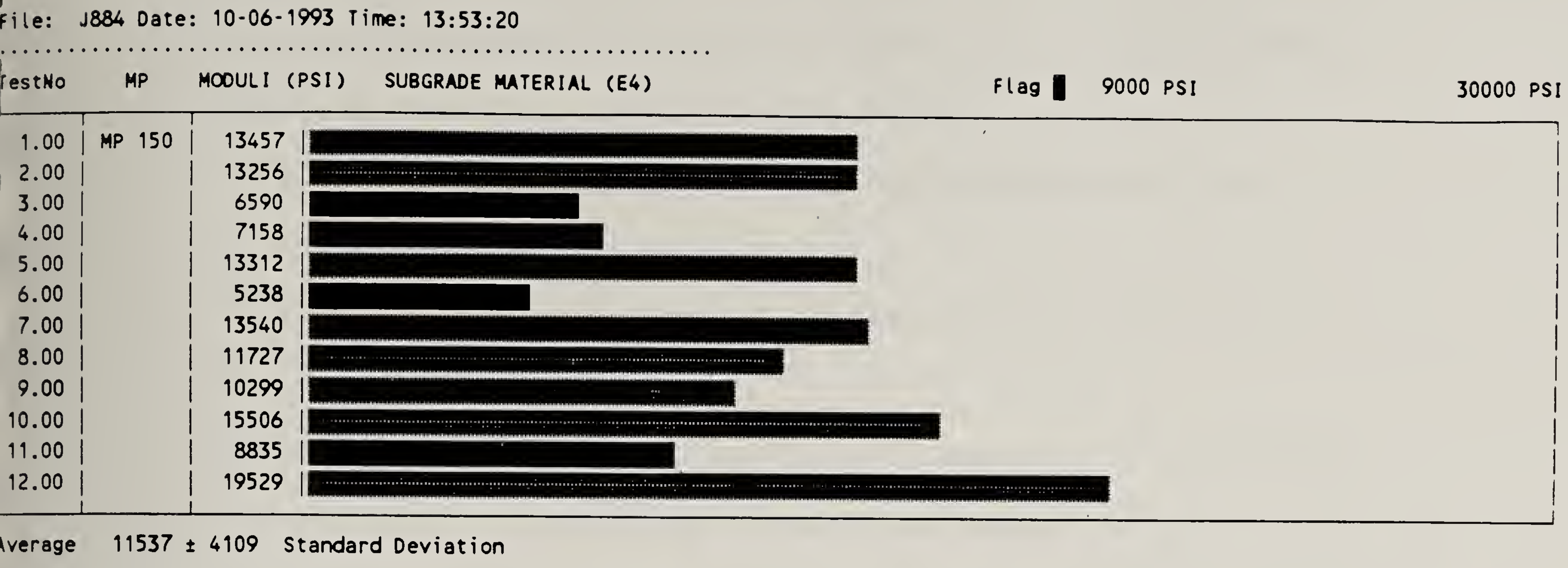


verage 451118 ± 50865 Standard Deviation

```
ile:  J884 Date: 10-06-1993 Time: 13:53:19
............................................................
```



Average 25419 ± 7945 Standard Deviation



```
File:  J884 Date: 10-06-1993 Time: 13:53:20
..........................................................
TestNo     MP     MODULI (PSI)   SUBGRADE MATERIAL (E4)          Flag ▮  9000 PSI          30000 PSI

  1.00 | MP 150 |  13457 |
  2.00 |        |  13256 |
  3.00 |        |   6590 |
  4.00 |        |   7158 |
  5.00 |        |  13312 |
  6.00 |        |   5238 |
  7.00 |        |  13540 |
  8.00 |        |  11727 |
  9.00 |        |  10299 |
 10.00 |        |  15506 |
 11.00 |        |   8835 |
 12.00 |        |  19529 |

Average   11537 ± 4109  Standard Deviation
```

PHASE C - DESIGN

Resilient Modulus Evaluation:

The backcalculated Mr should be reviewed and grouped based upon areas of similarity. Often times the groups will not be the same from layer to layer and this is acceptable.

The design phase consist of three independent programs - LIFE, MichPAVE and DARWin. The following variables must be known to run these programs:

Climatic station number
Design ESALs
Design Speed → typically 65 interstate & 60 all others
Road Rater testing frequency
Composition of the existing pavement structure
Resilient Modulus of all existing layers
SN of each layer
Drainage coefficients

LIFE:

The LIFE program is a purely mechanistic overlay design program that has two main objectives:

1) Determines remaining life and probable failure mechanism
2) Determines an overlay thickness for a given set of conditions.

This program is user friendly and requires no additional user manual. A series of questions appear on the screen and the user is prompted to respond. After the last question is answered, the program begins running. When completed, the results are displayed and a print option is displayed.

MichPAVE:

MichPAVE is a user-friendly, nonlinear finite element program for the analysis of pavements. Useful design information such as fatigue life and rut depth are estimated through empirical equations for three and four layer asphaltic surfacing sections. Displacements, stresses and strains due to a single circular wheel load are computed by the program.

MichPAVE uses menus to perform the required steps in pavement analysis, and data-entry forms to facilitate the easy input of data. In addition, extensive checking of input data is performed, and appropriate error messages are displayed after each data-entry form is completed.

The analysis portion of MichPAVE consists of an initialization part, several iterations, and a concluding part. After the analysis is completed, a design summary is displayed. The summary includes maximum tensile strain at the bottom of the asphalt, average compressive strain in the asphalt layer, maximum compressive strain at the top of the subgrade, the number of ESALs to cause fatigue failure and the rut depth at the time of the final ESAL application.

Rather than address every input required to successfully use MichPAVE, the "MichPAVE User's Manual" should be reviewed and utilized until familiarity is achieved.

DARWin:

In 1984-85 the "Subcommittee on Pavement Design" and a team of consultants revised the existing AASHTO design guide and issued a version entitled "AASHTO Guide for the Design of Pavement Structures - 1986." MDT referred to this program as DNPS/86 or New AASHTO and it was developed into a mechanistic/empirical design procedure. AASHTO has since introduced new pavement design software which it calls DARWin(Design, Analysis, and Rehabilitation for Windows). DARWin is a revised and enhanced version of New AASHTO that utilizes the Microsoft Windows environment to vastly improve its user friendliness and capabilities.

DARWin is essentially a tool that allows the engineer/pavement designer to spend more time evaluating

alternative new pavement designs and less time generating them. Although the program is simple enough to be operated by almost anyone, it should not take the place of the highway designer/engineer. A thorough understanding of the engineering fundamentals and principles associated with pavement design is essential to the proper application of this program.

DARWin is a user friendly menu driven software package with three main components; 1) Screen Program, this allows the user to input the various problemspecific data through a series of menus; 2) Analysis Program, this part carries out the actual design calculations; and 3) Control Program, this portion insures a smooth flow between the first two components.

Besides the capability of designing flexible or rigid surfacing sections, the DARWin program also has the capacity of considering planned rehabilitation as part of a design strategy. Although MDT does not currently use all options available within DARWin, maintenance cost considerations and benefit cost analysis options are also available.

DARWin is an excellent desing tool that is extensively utilized by MDT. For specific input guidelines and detailed program rules, consult the users guide entitled "Darwin Users Guide".

Project Level Summary:

The objective of Project Level NDT testing is to provide detailed and accurate design information to district personnel, Preconstruction and the Surfacing Design area. This goal is accomplished by accurately completing each phase of the Network program in a systematic manner. When reviewing this portion of the NDT area, it should be noted that each phase is dependent on the preceding. If any errors are left uncorrected, then the final recommendations may be incorrect and/or misleading. Always remember over design and under design waste valuable resources and money.

NETWORK EVALUATION

PHASE 1 - FIELD EVALUATION AND NDT TESTING

Network Level Testing Procedure

The Network Level Road Rater's main responsibility is to gather deflection data in sufficient quantity to determine the following:

1. Determine nominal overlay thicknesses to be used in preparation of scope of work reports and to perform future project programming.
2. Effective remaining life of the roadway.
3. NDT data for pavement life curve creation and revision.
4. Seasonal correlations and soil class correlations.

The testing frequency is less than the Project Level since the use of the data is different. The Federal-Aid System is divided into two groups for the Network Level. The two groups are NHS (National Highway System) and STP (Surface Transportation Program). The Interstate testing frequency is four tests per mile each direction. The testing frequency for all other routes is four tests per mile. Only one direction will be tested on two-lane roadways.

Following is the pattern and spacing of the network level testing for one mile of roadway:

```
                   0.0 mi.   .25 mi.   .50 mi.   .75 mi.  1.00 mi.
                                               3960′
                   - - - - - - - - - - - - - - - - - - - - - - - -
Interstate          0        1320′  2640′           5280′/0

                       0.0 mi.   .25 mi.   .50 mi.   .75 mi.  1.00 mi.

                   - - - - - - - - - - - - - - - - - - - - - - - - - -
2-lane testing*        0      1320′     2640′     3960′     5280′/0
```

* testing will be performed in <u>one direction only.</u>

Equipment that is needed for testing and must be checked before leaving Headquarters:

- Drill (don't forget periodic maintenance)
- Bits ½" and 1", at least two of each
- Mineral oil, at least one gallon should be obtained before leaving Headquarters
- Digital and infrared thermometers with spare batteries
- Air pressure in the Road Rater bladders must be checked
- Check oil in small engine in Road Rater
- Check oil in towing and flagging unit
- Check hydraulic oil in Road Rater
- Check periodic maintenance schedule (P.M.) for towing unit, flagging unit, and Road Rater.

Flagging Requirements

As a rule, maintenance forces are not needed for Network Level testing. Network Level testing will be performed by a crew of two (2) people. The Lab Specialist II will operate the Network Level Road Rater and direct the second person. The second person is responsible for flagging operations and should position his vehicle behind the Road Rater approximately 300′ with the right side tires on the shoulder stripe. However, the "follow" vehicle must be positioned so that approaching traffic (in the same direction of travel) has a minimum of 1,000′ to sight the flagging vehicle.

Flagging Equipment set-up:

The flagging vehicle must:

1) Connect sign to the rear of the vehicle
2) Turn on flashers and head lights
3) Turn on light bar
4) Check the two-way radio to ensure communication with the towing unit

The towing unit must:

1) Raise the arrow board into operating position and turn it on
2) Turn on flashers and headlights

3) Turn on amber lights
4) Check the two-way radio to ensure communication with the flagging vehicle

Road Rater Set-Up

1) Start the Road Rater
2) Using the switch, raise the mass
3) Remove the safety pins. There is one on each side located just above the front tire. Lift the pin up, then slide it out approximately 1½".
4) Lower the mass using the switch
5) Install the mast containing the four sensors **be sure to latch the sensor mast in place**
6) Turn off small engine and proceed with computer set-up

Computer Set-Up

1) Turn on the power converter
2) Turn on the PC
3) At the menu select the correct function for the project
4) All testing should be done with the printer on line

5) Follow the directions and fill in all necessary data

* Note The network file name will be the route number plus the direction of travel, e.g. east E, west W, north N, south S, plus the MP, e.g. 90E156 or P5N10

Temperature and Depth Determination

1) Drilling for surfacing depths is not required for the Network Level testing.

2) Drilling for average mat temperature must be done three times per day; once in the morning, once at mid-day, and once at the end of the day's testing.

   a) Drill a ½" hole ½ the expected mat thickness +1".
   b) Pour approximately a 2" depth of oil in the ½" hole.
   c) Allow X minutes for the oil to reach equilibrium.
   d) Put the temperature probe in the oil and turn on the thermometer.
   e) Read the normalized mean asphalt temperature.
   f) Record the temperature on the form and in the computer.

3) Begin the testing sequence -- refer to the diagram on the dash of the towing unit if there are questions about the sequence.

4) At each milepost, monitor and record the surface temperature using the infrared thermometer.

Surface Distress Monitoring

- Surface distress at each testing location should be recorded. Refer to the surface distress rating manual for the proper recording of the distress.
- Location of distress, presence of cuts or fills, presence of water, maintenance activities and other possible abnormalities should also be recorded.
- Surface distress abbreviations:

  ALG = Alligator cracking
  LNG = Longitudinal cracking
  POT = Pot holes
  PCH = Patch
  RUT = Rut
  TRN = Transverse cracking
- Other useful abbreviations:

  BR = Bridge
  CL = Centerline
  CUT = Cut
  FILL = Fill

MP = Milepost

WP = Wheel path

AH = Ahead

BH = Back

Water = Water (water location and amount should also be noted)

- In addition to the above abbreviations, extent and severity must also be recorded.

Testing Procedure

1) Begin one testing length after the end of the previous test.*
2) When asked for the station, enter the test number.
3) Enter the lane number. Skip one number for the median on the Interstate system.
4) Enter the note. This is the area to enter the distress, temperatures, etc. Refer to "Temperature and Depth Determination" and "Surface Distress Monitoring."
5) On the note comment at the MP locations use this format: Note: MP110 SURF71 (comments if needed)
5) Perform the testing.
6) Check the deflection recordings. If the deflections are in descending order, then accept the test. If the deflections are not, then reject and retest.
7) Continue with temperature monitoring as previously directed.

8) Repeat the testing procedure at the designated intervals.
9) End the testing at an easily documentable location.

* Careful documentation is required to ensure that there is no testing duplication or gaps.

Shut Down Procedure

1) Move the Road Rater and towing unit as far off the roadway as possible
2) Turn the computer off
3) Manually lower the mass
4) Remove the mast and the sensors
5) Manually raise the mass and turn off the Road Rater engine
6) Insert the pins to secure the mass
7) Lower and secure the arrow board on the towing unit
8) Turn off the arrow board and flashers
9) Remove signs and turn off all warning lights on the flagging vehicle

Because of the number of lane miles in Montana's highway network, complete monitoring will be accomplished on a two-year cycle. The NHS system will be rated on odd numbered years and the STP system will be rated on even numbered years. Seasonal testing and soil class testing will be performed on a yearly basis.

Daily production is expected to be approximately 30 four-lane miles per day, this includes travel time.

PHASE 2 - NDT DATA MANIPULATION

Transfer of Data

This step is required to take the raw field data and put it on the network computer in the required format(s).

1) The network must be connected
2) Go to NDT Network Menu
3) Go to NDT Network Data Menu
4) Select Edit Raw R.R. Data on Disk
5) Select the drive the raw data disk will be in

*6) Enter the name of the file to be checked/edited

7) Save all changes (F3)
8) Convert the edited raw data format
    - designate the location of the edited raw data
    - enter the edited raw data file name
9) Follow the menu direction until conversion is complete
10) Repeat steps 1 thru 9 until all files are converted.

* Using SPFPC, the raw data must be checked for sequential test numbers, checked for sequential milepost comments and make any other required corrections.

The "whereis" function should be used periodically as a check of the system. This will ensure that the converted files are being copied as directed.

PHASE 3 - NDT DATA INTERPRETATION AND EVALUATION

When the entire season's Network data is transferred, Phase 3 begins.

Using SPFPC, the raw data should be reviewed to insure there are no missing tests or format errors. Once it is determined that all deflection data exists and is correct, files must be merged to enable backcalculation. The surfacing thickness file, traffic (ESALs) file and the deflection file must be merged.

The merged data must then be ran thru MODULUS following the same procedure as documented in the "Project Level Backcalculation." When backcalculation is complete, the Mr of each existing layer should be written to the permanent VAX data file.

Utilizing the "LIFE" program, the effective overlay thickness should then be calculated for each mile of the roadway. The resulting effective overlay, should then be written to the permanent VAX data file.

Because of the fact that the Network Level testing is a programming and projection tool, detailed evaluation (like Project Level) is not required.

PHASE 4 - FORMALIZATION AND TRANSMITTAL OF NDT RESULTS

There are three main areas that require the Network Level information. They are: 1) Strategic Planning; 2) District Engineers; and 3) Pavement Management. Each area may require a different format. The following list is the current formats available; however, based on user requirements, this list may change.

1) Straight-line graph of each route and its "effective overlay" thickness.
2) Straight-line graph of each route's structural remaining life.
3) Summary of the Route's ranges of remaining life.
4) Summary of the route's ranges of "effective overlay"
*5) Computer file of deflections, stiffness and resilient modulus of each layer

*This is typically only provided to Pavement Management for the updating of the structural pavement life curve(s).

SUMMARY

The objective of the Network Level NDT testing is to provide a mile by mile summary of the structural integrity, remaining life, effective overlay and deflection data to all parties involved in planning, prioritizing, nominating or forecasting.

The users of this data must always be reminded that the Network Level testing is not sufficient for design. This is because Surfacing Design analyzes additional non-NDT information as well as Project level NDT data before making official surfacing recommendations. For specific design information, concerned parties should be directed to the Surfacing Design Area.

Because of the recent creation of the Network Level program, there is no historical record to compare the data to. Until a historical record exists, the usefulness of all generated output will not be certain. For this reason, suggestions and comments from the users should be encouraged. User suggested modifications should be made if at all possible. By modifying the system based on the users' concerns, the Network Level program will quickly develop into a system that is tailored to the "customer."

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